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Lijun Qian

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Prairie View A&M University
P.O. Box 667

Prairie View, TX 77446 -0667

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14. ABSTRACT

During the funding period, a set of state-of-the-art software defined radio platforms are acquired, including 10 NI USRP-2932 (400MHz~4.4GHz + GPS Clock) Software Radio Kit, 3 NI USRP-2942R (400MHZ~4.4GHz with KINTEX-7 FPGA), and 3 NI USRP-2952R (400MHZ~4.4GHZ with GPS). These software defined radio platforms provide the much needed infrastructure support for cognitive radio research. In addition, a commercial grade NI spectrum analyzer and vector signal generator have been acquired to serve as benchmark for validation and testing. A Dell PowerEdge R920 storage server is acquired for RF traces collection and storage. In addition, 10 graduate

15. SUBJECT TERMS

Cognitive Radio; Wireless Networks

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a. REPORT	b. ABSTRACT	c. THIS PAGE			Lijun Qian
UU	UU	UU	UU		19b. TELEPHONE NUMBER 936-261-9908

Report Title

Final Report: Acquisition and Development of A Cognitive Radio based Wireless Monitoring and Surveillance Testbed for Future Battlefield Communications Research

ABSTRACT

During the funding period, a set of state-of-the-art software defined radio platforms are acquired, including 10 NI USRP-2932 (400MHz~4.4GHz + GPS Clock) Software Radio Kit, 3 NI USRP-2942R (400MHZ~4.4GHz with KINTEX-7 FPGA), and 3 NI USRP-2952R (400MHZ~4.4GHZ with GPS). These software defined radio platforms provide the much needed infrastructure support for cognitive radio research. In addition, a commercial grade NI spectrum analyzer and vector signal generator have been acquired to serve as benchmark for validation and testing. A Dell PowerEdge R920 storage server is acquired for RF traces collection and storage. In addition, 10 graduate students and myself participated in the USRP/GNUradio training by the National Instruments Inc. on October 16-17, 2014. We have gained valuable knowledge and hands-on experiences of experimental systems and software implementations of cognitive radio using COTS devices. A distributed RF traces collection and wireless surveillance test bed and a hierarchical wireless network test bed have been implemented and currently under testing. Many students actively participated in the projects and obtain valuable hands-on experience. The students also demonstrated the test beds to Dr. Robert Ulman, program manager at the Network Science Division of the Army Research Office, during a site visit on October 29 2014.

Enter List of papers submitted or published that acknowledge ARO support from the start of the project to the date of this printing. List the papers, including journal references, in the following categories:

(a) Papers published in peer-reviewed journals (N/A for none)

Received	Paper

TOTAL:

Number of Papers published in peer-reviewed journals:

(b) Papers published in non-peer-reviewed journals (N/A for none)

Received	Paper

TOTAL:

Number of Papers published in non peer-reviewed journals:

(c) Presentations

Number of Presentations: 0.00

Non Peer-Reviewed Conference Proceeding publications (other than abstracts):

Received	Paper

TOTAL:

Number of Non Peer-Reviewed Conference Proceeding publications (other than abstracts):

Peer-Reviewed Conference Proceeding publications (other than abstracts):

Received	Paper	
03/01/2015	1.00	Oluwaseyi Omotere, Opeyemi Oduola, Nan Zou, Xiangfang Li, Husheng Li, Lijun Qian. Distributed Spectrum Monitoring and Surveillance using a Cognitive Radio based Testbed, International Conference on Testbeds and Research Infrastructures for the Development of Networks & Communities (TRIDENTCOM 2015). 23-JUN-15, . : ,

TOTAL: **1**

Number of Peer-Reviewed Conference Proceeding publications (other than abstracts):

(d) Manuscripts

Received	Paper

TOTAL:

Number of Manuscripts:

Books

Received Book

TOTAL:

Received Book Chapter

TOTAL:

Patents Submitted

Patents Awarded

Awards

Graduate Students

NAME	PERCENT_SUPPORTED

FTE Equivalent:
Total Number:

Names of Post Doctorates

NAME	PERCENT_SUPPORTED

FTE Equivalent:
Total Number:

Names of Faculty Supported

NAME	PERCENT_SUPPORTED

FTE Equivalent:
Total Number:

Names of Under Graduate students supported

NAME	PERCENT_SUPPORTED

FTE Equivalent:
Total Number:

Student Metrics

This section only applies to graduating undergraduates supported by this agreement in this reporting period

The number of undergraduates funded by this agreement who graduated during this period: 0.00
The number of undergraduates funded by this agreement who graduated during this period with a degree in science, mathematics, engineering, or technology fields:..... 0.00
The number of undergraduates funded by your agreement who graduated during this period and will continue to pursue a graduate or Ph.D. degree in science, mathematics, engineering, or technology fields:..... 0.00
Number of graduating undergraduates who achieved a 3.5 GPA to 4.0 (4.0 max scale):..... 0.00
Number of graduating undergraduates funded by a DoD funded Center of Excellence grant for Education, Research and Engineering:..... 0.00
The number of undergraduates funded by your agreement who graduated during this period and intend to work for the Department of Defense 0.00
The number of undergraduates funded by your agreement who graduated during this period and will receive scholarships or fellowships for further studies in science, mathematics, engineering or technology fields: 0.00

Names of Personnel receiving masters degrees

NAME

Total Number:

Names of personnel receiving PHDs

NAME
Ojemba Babatundi

Total Number: **1**

Names of other research staff

NAME	PERCENT_SUPPORTED

FTE Equivalent:
Total Number:

Sub Contractors (DD882)

Inventions (DD882)

Scientific Progress

During this funding period (Jan 2014 - Jan 2015), the PI and team have been working on all the tasks proposed for the project. Specifically, a set of state-of-the-art software defined radio platforms are acquired, including 10 NI USRP-2932 (400MHz~4. 4GHz + GPS Clock) Software Radio Kit, 3 NI USRP-2942R (400MHZ~4.4GHz with KINTEX-7 FPGA), and 3 NI USRP-2952R (400MHZ~4.4GHZ with GPS). These software defined radio platforms provide the much needed infrastructure support for cognitive radio research. In addition, a commercial grade NI spectrum analyzer and vector signal generator have been acquired to serve as benchmark for validation and testing. A Dell PowerEdge R920 storage server is acquired for RF traces collection and storage. A distributed RF traces collection and wireless surveillance test bed and a hierarchical wireless network test bed have been implemented and currently under testing. Many students actively participated in the projects and obtain valuable hands-on experience.

Here we report important results from the implementation of the distributed RF traces collection and wireless surveillance test bed and a hierarchical wireless network test bed. Deploying USRPs for the distributed RF trace collection testbed instead of the NI PXI system offers flexibility, affordability and its easy programmability are key strengths of the NI USRP platform. As a PC-hosted peripheral that is programmable with NI LabVIEW, the NI USRP radio transceiver excels at these, this is due to the modular nature of the USRP compare to bulky nature of the PXI system. The PXI system is expensive to setup, if we consider the number of PXI required in spectrum surveillance application, the cost implication makes it unrealistic. We have described the centralized and distributed RF trace collection testbed, which has been built for spectrum monitoring and surveillance with superior visibility and controllability compared to WiFi-based solutions. In addition, the testbed is a programmable yet fully controlled setup for implementation and testing of design of MIMO system and to evaluate different machine learning techniques. As for the hierarchical wireless network consisting of both USRP2s and XBOW MicaZ sensor motes, we used a total of three USRP2s and six XBOW MicaZ sensor motes. Two USRPs served as cluster heads. The function of these USRP2s were to receive measurement data from six sensor motes simultaneously and transmit the information to a central control USRP2. The central control then translated the raw data of packet to engineering units and displayed them on a monitoring station. Furthermore, the central control can control each sensor individually by sending commands to the motes. The main advantages of using USPR2 with GNU Radio are software based signal processing, communication range extension and using the USRP2's wideband nature to capture multiple IEEE 802.15.4 channels simultaneously. We faced several challenges in building this testbed, including programming the XBOW MicaZ motes, understanding the UCLA Zigbee files, and extensively modifying the relevant programs. Once we were able to overcome these challenges, we integrated those components to create a functioning hierarchical SDR controlled WSN testbed that will be of benefit to future research in this area.

Technology Transfer

The spectrum monitoring and surveillance system developed may have potential for technology transfer.